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Some Innovative Approach to the Basic Principle of Damage Sensor Using Mechanoluminescence Technique

MANAS KUMAR SAHU

Indira Kala Sangit Vishwavidyalaya, Khairagarh, C.G., INDIA.

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ABSTRACT

The intense mechanoluminescence materials investigated in the recent past have proved to be useful for damage sensors. An intense fracto-mecmanoluminescent material embedded in or attached on to a composite structure acts as a real-time damage sensor. In this technique, each location of the structure either comprises different ML materials or all locations use the same ML material in which different fluorescent dyes are mixed for different wavelengths-shifting at different locations. When an impact fractures the material, it send a flash of light through optical fibers to the detector, whereby the intensity of light directly gives the magnitude of the damage and the wavelength of the light emitted indicates the location of damage caused by the dynamic events.

Keywords: Mechanoluminescence materials, Real-time damage sensor.

INTRODUCTION

Cold emission of light is known as luminescence. Mechanoluminescence (ML) is the phenomenon of light from a solid as a response to mechanical stimulus. The light emission induced by elastic deformation, plastic deformation and fracture of solids are known as elastic ML, plastic ML and fracto ML, respectively. Whereas only a few materials exhibits ML during their elastic and plastic deformation, nearly 50% of all inorganic salts and organic molecular solids exhibit ML during their fracture. The ML of impure saccharin, ditriphenylphosphin oxide manganese bromide, europium tetrakis (dibrnzoylmethide) triethyl ammonium, rare earth doped strontium aluminates, etc. is so intense that it can be seen in day light with naked eye.

As ML emission is associated with stress, fracture and damage in solids, such in herent behavior of ML materials has been exploited to fabricate mechanoluminescents stress, fracture and damage sensors. The present paper reports the some innovative approach to the basic principle of damage sensor using mechanoluminescence technique.

MECHANOLUMINECENT DAMAGE SENSORS

The mechanoluminescent materials which emit intense light when they are fractured have been developed by Bourhil and his co –workers of Defence Evaluation and Research Agency, United Kingdom as real-time optical damage sensor[1-4]. In this technique, the fracto-mechanoluminescence material of several micron size is mixed in liquid resin and then cured at between 120and 200^{o}C, whereby the occurrence and severity of the damage is given by the intensity of the resulting mechano-luminescencent light. Monitoring of the position of damage is achieved either by designing an array of sensors, with eacg sensor in the array comprising a different mechanoluminescencent material and thus, mechanoluminescsncing over a discrete wavelength rang, or by designing an array of mechanoluminescencent sensors with each and every sensor having the same type of mechanoluminescencent material whereby a wavelength-shifting is produced using a range of conventional fluorescent dyes in which the mechanoluminescence from doped resin pumps the dye, which then emits at a different wavelength. Such an arrangement allows location monitoring simply by detecting thr wavelength of the emitted light.

The intence mechanoluminescent materials like Eu, Tb or Mn complexes, ester, acetyl complex, asperin derivative, carboxylate, salsalate, etc, have been found suitable for mechanoluminescentdamage sensors MY75V, MY956 or MY750/HY917 Ciba resins have been used, successfully as binders. Now, it has become possible to coat a multimode silicon fiber with a doped resin and embed it in a glass-fiber reinforced plastic. Scientists, have succeeded in doping composite structures for aircraft with fine mechanoluminescent crystals. The ultimate objective is to fit an aeroplane with a “pain-sensitive skin” containing a “nervous system” of embedded optical fibers. When an impact cracks the doped resin, it sends a tiny flash of analogous to a pain signal along the fibers to a detector. Thus the intensity of light directly gives the magnitude of the damage and the wavelength of the light emitted indicates the location of damage, for example, it discriminates between impact to a tailfins or wing.

CONCLUSIONS

The important conclusions drawn from the present investigation are as below:

(i) The intense mechanoluminescent materials investigated in the recent past have prove to be useful for damage sensors.

(ii) The investigation on the optical response mechanoluminescent materials to pressure pluses of short duration, ultrasonic waves, and shock-waves induced by laser pulsed infrared lasers may be interesting.

(iii) The mechanoluminescent sensors could fine applications in giving prior information of earthquakes, mine failure and bridge failure.

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